Before the FEDERAL COMMUNICATIONS COMMISSION Washington, DC 20554

In the Matter of)	
)	
Expanding the Economic and Innovation)	Docket No. 12-268
Opportunities of Spectrum Through Incentive)	
Auctions)	
)	

COMMENTS OF CLEARWIRE CORPORATION

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EXECUTIVE SUMMARY

Clearwire commends the Commission for seeking comment on alternative band plans for the 600 MHz band. The band plan is just one piece of the highly complex broadcast incentive auction, and an important step in bringing the reclaimed 600 MHz spectrum to market for wireless use. Clearwire believes that due to the complexities of the incentive auction, a Time Division Duplexing ("TDD") band plan would best allow the Commission to achieve its goal. Thus, Clearwire urges the Commission to adopt the "Down from 51" TDD band plan.

As the architect of the country's first greenfield 4G wireless network, Clearwire capitalized on the Commission's foresight in providing full and flexible use of the 2.5GHz band by choosing to couple unpaired spectrum with WiMAX, a TDD technology. In choosing its platform for the future, Clearwire analyzed both TDD- and Frequency Division Duplexing ("FDD")- LTE technologies and chose TDD-LTE. TDD technologies have many attributes – including being well suited for asymmetric operations and non-uniform spectrum assets – that also make it an attractive option for the new 600 MHz band plan. Clearwire has also found that the flexibility afforded by TDD technology allows it to customize its network to meet consumer demands for intensive and growing data consumption, another feature that makes TDD an attractive choice for the 600 MHz band. Clearwire, therefore, urges the Commission to adopt the "Down from 51" TDD band plan, as it allows the Commission to better meet its goals for the incentive auction.

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Clearwire Corporation ("Clearwire"), pursuant to Section 1.405 of the Federal Communications Commission's (the "Commission") rules, submits these comments in response to the Commission's Public Notice ("PN") in the above-captioned proceeding seeking to supplement the record on the 600 MHz band plan.²

I. **BACKGROUND**

Clearwire is a leading provider of 4G wireless broadband services and offers 4G wireless broadband services in 80 markets covering more than 133 million Americans. Clearwire serves retail customers through its own CLEAR® brand as well as through wholesale relationships with some of the leading companies in the retail, technology and telecommunications industries, including Sprint and NetZero.

Since the Commission revised its 2.5 GHz regulations to promote a capacity-rich 4G mobile broadband network,³ Clearwire has deployed its network at record-breaking speed.⁴ As

¹ 47 C.F.R. § 1.405.

² Wireless Telecommunications Bureau Seeks to Supplement the Record on the 600 MHz Band Plan, GN Docket No. 12-268, Public Notice, DA 13-1157 (rel. May 17, 2013) ("Band Plan PN").

³ See Amendment of Parts 1, 21, 73, 74 and 101 of the Commission's Rules to Facilitate the Provision of Fixed and Mobile Broadband Access, Educational and Other Advanced Services in the 2150-2162 and 2500-2690

of April 25, 2013, Clearwire's network serves approximately 9.4 million total subscribers.⁵ To support deployment, Clearwire relies upon BRS licenses and excess capacity leases from other BRS and EBS licensees.⁶

Clearwire offers a consumer-friendly "no contract" option and unlimited data plans under the brand name CLEAR®. It also offers its advanced wireless broadband service on a non-exclusive wholesale basis.⁷ Clearwire continues to position itself as a capacity-rich "off ramp" for other carriers facing spectrum constraints. Clearwire has begun deployment of its TDD-LTE 4G overlay network designed to provide wholesale capacity in dense urban markets where it is needed most.⁸

MHz Bands, Report and Order and Further Notice of Proposed Rulemaking, WT Docket No. 03-66 (Jul. 29, 2004) ("2.5 GHz R&O").

⁴ Clearwire launched its first greenfield 4G network in Portland, Oregon in early 2009.

⁵ The 9.4 million subscribers consist of 1.5 million retail subscribers and 7.9 million wholesale subscribers with high-speed residential and mobile Internet and interconnected voice over Internet protocol ("VoIP") services.

⁶ As part of its relationship with its EBS lessors, Clearwire assists its EBS lessors in meeting their obligations under FCC rules to use their spectrum to provide essential educational services to schools and colleges across the country.

Clearwire provides the broadband platform serving Sprint's 4G customers along with a group of disruptive upstarts including FreedomPop, NetZero, Karma, Mobile Beacon, Mobile Citizen, Leap Wireless, Cbeyond and Locus Telecommunications. These newcomers are using Clearwire's network to offer innovative pricing models, including free broadband to consumers. *See* Anton Troianovski, *Start-Up Skirts Cellphone Data Plans* (Oct. 1, 2012) , available at http://online.wsj.com/article/SB10000872396390443862604578028452045153628.html?mod=googlenews_ws j; *see also* Myriam Joire, *NetZero Launches '4G' Wireless Service, We Go Hands on* (Mar. 19, 2012), available at http://www.engadget.com/2012/03/19/netzero-launches-4g-wireless-service-we-go-hands-on/; Karl Bode, *Karma Offers Wireless at \$14 a Gigabyte, Straight Latest MVNO Attempt to Disrupt Pricing*, available at http://www.dslreports.com/shownews/Karma-Offers-Wireless-at-14-a-Gigabyte-Straight-119948 (Jun. 15, 2012); Tammy Parker, *WiMAX Provider Mobile Beacon Offers Free Wi-Fi Service* (Sep. 23, 2012), available at http://www.fiercebroadbandwireless.com/story/wimax-provider-mobile-beacon-offers-free-wi-fi-service/2012-09-23.

⁸ See Kevin Fitchard, Clearwire Breaking Ground on New LTE Network (Sep. 20, 2012), available at http://gigaom.com/2012/09/20/clearwire-breaking-ground-on-new-lte-network/. Clearwire initially is targeting high demand "hot zones" in 31 major urban centers such as New York City, San Francisco, Los Angeles, Chicago, and Seattle where demand for 4G mobile broadband is high and the need for deep capacity resources is most acute.

II. THE COMMISSION SHOULD ADOPT THE "DOWN FROM 51" TDD APPROACH

In the Band Plan PN, the Commission asked for comments to supplement the record on several alternative band plans put forth in the previous round of comments and expounded upon at a May 3, 2013 workshop hosted by the Commission. Among the band plans set up for comment in the PN is a "Down from 51" TDD approach that Clearwire endorses as a superior alternative to plans based upon FDD technology that seek to maximize paired spectrum. In its comments and as a participant at the workshop, Clearwire described its experience as the architect of the country's first greenfield 4G wireless network and its decision to launch WiMAX, a TDD technology. Further, Clearwire explained that in choosing its platform for the future, Clearwire analyzed both TDD- and FDD- LTE technologies and chose TDD-LTE. TDD technologies have many attributes – including being well suited for asymmetric operations and non-uniform spectrum assets – that also make it an attractive option for the new 600 MHz band plan.

Both FDD- and TDD- LTE networks and hybrid FDD/TDD networks are being deployed across the globe, utilizing the respective advantages of each technology. In considering the appropriate band plan and technical rules for the relinquished broadcast TV spectrum, the Commission should take note of the burgeoning, global adoption of TDD technologies by datacentric newcomers such as Clearwire and the superior utility of TDD technologies where traffic is asymmetric and spectrum availability is non-uniform across geographic licensing areas. Clearwire, therefore, urges the Commission to adopt a TDD based band plan for the new 600 MHz band.

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⁹ Band Plan PN at 5.

¹⁰ Pand Plan PN at 6

A. TDD Technologies are Particularly Well-suited for Asymmetric Traffic and Non-Uniform Geographic Spectrum Availability

The one thing everyone agrees on is that implementation of the many steps required for a successful broadcast incentive auction is going to be complicated. Questions loom regarding how much broadcast spectrum will be made available and where that spectrum will be located. Clearwire, which is permitted to deploy FDD or TDD technologies in the 2.5 GHz Band, built its 4G network on a licensing scheme that shares several important characteristics with the returned broadcast spectrum. As the Commission explains at length, depending on the outcome of the reverse auction, the Commission anticipates that there will be "non-uniform amounts of relinquished broadcast TV spectrum in each geographic area." Clearwire, similarly, has built its 4G network on a somewhat fractured band plan, because Clearwire's 2.5 GHz spectrum portfolio is assembled from owned or leased channels that differ from one geographic area to another. Additionally, Clearwire's network has been designed to accommodate intensive and escalating demands for high capacity data services. Similarly, the Commission expects that the relinquished broadcast spectrum will be deployed to address the burgeoning demands of datacentric devices and applications. Both these factors – an uneven spectrum allocation and datacentric demand – point to TDD as a logical technology choice.

1. TDD Can Adapt to an Uneven Spectrum Allocation Across Geographic Markets

The first factor that caused Clearwire to adopt TDD included the ability to use every megahertz of its spectrum and to configure it in different ways depending upon the channels available to it in a particular geographic area. FDD systems use a fixed, symmetric ratio of uplink to downlink spectrum that is necessarily separated by a "duplex gap" that is set by

regulatory rule.¹¹ TDD technologies, however, permit the system operator to allocate its spectrum resources between uplink and downlink demand and allow for a variety of channel plans depending upon spectrum availability in a particular geographic area. In its LTE trials, Clearwire tested TDD and FDD configurations.¹² Clearwire ultimately chose TDD, in large measure because it would not require a duplex gap, permitting Clearwire to deploy an uninterrupted succession of LTE carriers across the 2.5 GHz band. And as Sprint explained in its comments, "[w]here spectrum is scarce, artificially bifurcating a band into dedicated uplink and downlink channels, with intervening duplex gaps, makes little spectrum policy sense."¹³

The predictions for the amount spectrum that will be returned for auction by broadcasters vary from as high as 156 MHz down to 60 MHz, with the possibility of wide variation across markets. Indeed, the Commission has already expressed its desire to "account for the possibility that there may be some markets in which there is very low participation or technical constraints due to coordination with Mexico and Canada." Despite these possibilities, a number of proponents of FDD band plans have proposed that the Commission maximize paired spectrum and reserve any residual spectrum as unpaired supplemental downlink spectrum. This proposal does not take into account markets where insufficient paired spectrum is made available. In addition, in cases where a paired license is achievable, it potentially creates a supplemental downlink license as a consolation prize. A supplemental downlink license will

¹¹ See Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions, GN Docket No. 12-268, *Notice of Proposed Rulemaking*, FCC 12-118 at ¶ 166-67 (rel. Oct. 2, 2012) ("NPRM").

¹² See, e.g., Kevin Fitchard, 4G World: Clearwire paving way for 100 Mb/s, Connected Planet, Oct. 20, 2012, available at http://connectedplanetonline.com/3g4g/news/4G-World-Clearwire-paving-way-for-100-Mbs-1020/index.html.

¹³ Comments of Sprint Nextel at 18.

¹⁴ LEARN Workshop – 600 MHz Band Plan, Federal Communications Commission, Chris Helzer, Engineer, Broadband Division, Wireless Telecommunications Bureau at 13 (May 3, 2012) ("LEARN Workshop").

¹⁵ LEARN Workshop, Chris Helzer, FCC at 13.

¹⁶ See, e.g., Reply Comments of T-Mobile at 10.

only be of value to an incumbent provider that has sufficient spectrum resources to match it with uplink spectrum and thus will be of limited utility to new or smaller operators with limited existing spectrum resources. Sprint explained that should the Commission attempt to address asymmetrical data demands through a supplemental downlink allocation, it may "magnify spectrum aggregation problems and depress auction revenue."

In contrast, the flexibility afforded by TDD would permit all spectrum to be used for mobile broadband, regardless of the amount of returned spectrum without any "leftover" spectrum. Because TDD does not require dedicated uplink or downlink spectrum, it is the right choice where there is potentially wide variations in available spectrum. As George Harter, Clearwire's Director of RAN Architecture and Development, explained at the recent LEARN Workshop, "TDD gave [Clearwire] the flexibility to move within the band when channels weren't available or there were other operators that we had to deal with."

For example, when the FCC transitioned the 2.5 GHz band to a band plan that accommodates wireless broadband it divided the band into distinct segments to separate mobile broadband from legacy, high powered video operations. ¹⁹ Video operations are therefore permitted in the so-called 2.5 GHz "midband" but the midband can also be used for broadband in geographic areas where little or no video operations are present. The flexibility afforded by TDD allows Clearwire to utilize different channel configurations in markets like Los Angeles, where

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¹⁷ Comments of Sprint Nextel at 20.

¹⁸ LEARN Workshop, George Harter, Clearwire at 202.

Amendment of Parts 1, 21, 73, 74 and 101 of the Commission's Rules to Facilitate the Provision of Fixed and Mobile Broadband Access, Educational and Other Advanced Services in the 2150-2162 and 2500-2690 MHz Bands; Part 1 of the Commission's Rules - Further Competitive Bidding Procedures; Amendment of Parts 21 and 74 to Enable Multipoint Distribution Service and the Instructional Television Fixed Service Amendment of Parts 21 and 74 to Engage in Fixed Two-Way Transmissions; Amendment of Parts 21 and 74 of the Commission's Rules With Regard to Licensing in the Multipoint Distribution Service and in the Instructional Television Fixed Service for the Gulf of Mexico; Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, WT Docket Nos. 03-66, 03-67, 02-68, 00-230, MM Docket No. 97-217, Report and Order and Further Notice of Proposed Rulemaking, ¶ 44 (rel. Jul. 29, 2004).

video occupies the entire 2.5 GHz midband, Chicago where the midband is occupied both by WiMAX and video, and Atlanta, where WiMAX is used in the entire band. A similar scenario is likely to play out in the 600 MHz band as incoming mobile broadband providers contend with incumbent broadcasters and varying channel configurations across geographic markets. FDD technology, based on paired spectrum set by rule, would not accommodate a wide variation in channel configurations needed to address such issues.

In addition, if an FDD band plan is chosen, variability of available spectrum across different markets may lead to increased costs or different Third Generation Partnership Project ("3GPP")²⁰ band classes covering the same spectrum band, an issue encountered in the 700 MHz band with LTE bands 12 and 17.²¹ A TDD band plan would require only one band class definition that would widen the potential 600 MHz ecosystem rather than splintering it into many smaller pieces. As the Commission noted, a TDD band plan is "very good for supporting a wide variety of auction results."²²

2. TDD Can Accommodate Asymmetric Traffic Demands

Unlike FDD, TDD allows an operator to configure allocation of channel capacity between uplink and downlink to match traffic demands (at a market level), so for any given amount of spectrum, TDD technologies can be configured to be more spectrally efficient than FDD. It is this configurability that gives TDD technologies a key advantage over FDD and it is the reason why it has proven to be the technology of choice for nearly all Internet-centered or data-centered technologies, including LTE, WiFi, WiMAX, WiBro, Expedience, 802.20, PHS, IP-Wireless, Flarion, iBurst and Navini. In describing one of the benefits of a TDD band plan,

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²⁰ 3GPP unites a number of standard development organizations to produce reports and specifications. See "About 3GPP" available at http://www.3gpp.org/About-3GPP.

²¹ See Reply Comments of Competitive Carriers Association at 11.

²² LEARN Workshop, Chris Helzer, FCC at 21.

Alcatel explained that "[a] TDD approach may better provide the maximum amount of spectrum with both uplink and downlink capabilities . . ."²³

Unlike FDD where downlink-to-uplink ratios are immutable and set by rule, TDD technology allows an operator to set its downlink-to-uplink ratio to adjust to asymmetric data traffic. Adjacent operators avoid interference by synchronizing their downlink-to-uplink ratios and S frame configurations with each other. Clearwire currently utilizes a 3:2 downlink-to-uplink ratio. This ratio allows Clearwire to meet the demand on the downlink for capacity and throughput, while balancing the uplink link budget.²⁴ The concerns expressed in the record and during the workshop regarding the ability of TDD operators to agree upon a downlink-to-uplink ratio are unfounded.²⁵ The choices for ratios are determined by 3GPP and the operators involved have every incentive to work together to set a ratio that is mutually beneficial. Below are the LTE TDD frame configurations:

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²³ Comments of Alcatel Lucent at 3.

²⁴ LEARN Workshop, George Harter, Clearwire at 204-205.

²⁵ See LEARN Workshop, Darryl DeGruy, US Cellular at 147; See also Reply Comments of Verizon at 6.

Configuration	DL:UL	Downlink Subframes	Uplink Subframes	Special Subframes	Advantages/Disadvantages
0 (2:3) DSUUU_DSUUU	2:3	2	6	2	Better cell edge coverage by 2.3 dB. 58% loss in downlink throughput as compared to 1
1 (3:2) DSUUD_DSUUD	3:2	4	4	2	Good balance between coverage and capacity. Clearwire currently uses this configuration
2 (4:1) DSUDD_DSUDD	4:1	6	2	2	3 dB loss in uplink coverage as compared to 1 for same target uplink data rate
3 (7:3) DSUUU_DDDDD	7:3	6	3	1	1.1 dB loss in uplink coverage as compared to 1 for same target uplink data rate
4 (8:2) DSUUD_DDDDD	8:2	7	2	1	3 dB loss in uplink coverage as compared to 1 for same target uplink data rate
5 (9:1) DSUDD_DDDDD	9:1	8	1	1	6 dB loss in uplink coverage as compared to 1 for same target uplink data rate
6 (5:5) DSUUU_DSUUD	5:5	3	5	2	Better cell edge coverage by 1.3 dB. 25% loss in downlink throughput as compared to 1

LTE TDD Frame Configurations²⁶

In Clearwire's experience, synchronization proved extremely successful when a number of operators, including Clearwire, Sprint, and others worked together to set a downlink-to-uplink ratio for the 2.5 GHz band. When utilizing LTE TDD, the synchronization ratio allows operators to eliminate base station transmit to base station receiver interference for base stations that are within 133 miles of each other which, for all practical purposes, means that interference is highly unlikely. If the Commission does move forward with a TDD band plan, interference rules for the 600 MHz band should mirror the antenna height benchmarking coordination matrix as defined in Part 27 for BRS and EBS stations. If, for some reason, an operator refuses to agree to a synchronization ratio, the Commission should establish by rule a default TDD configuration and an S Frame configuration. Under those circumstances, Clearwire recommends TDD configuration 1 and S Frame 0. Because the default will be the most conservative choice from an interference perspective, it will promote a negotiated agreement among operators in the unlikely

²⁶ Table is adapted from 3GPP 36.101.

case that there are any uncooperative outliers. Below is a table of LTE TDD S Frame Configurations with TDD desynchronization distances:

DownPilot Time	DwPTS	GP	UpPTS	Distance Before BS	Distance Before
Slot/Guard Period/UpPilot	(Downlink	(Guard	(Uplink	to BS interference	BS to BS
Time Slot Configuration	Symbols)	Period	Symbols)	occurs (KM)	interference
		Symbols)			occurs (mi)
0-3:10:1	3	10	1	214.4	133.2
1-9:4:1	9	4	1	85.7	53.3
2-10:3:1	10	3	1	64.3	39.9
3-11:2:1	11	2	1	42.8	26.6
4-12:1:1	12	1	1	21.4	13.3
5-3:9:2	3	9	2	192.9	119.9
6-9:3:2	9	3	2	64.3	39.9
7-10:2:2	10	2	2	42.8	26.6
8-11:1:2	11	1	2	21.4	13.3
8-11:1:2	11	1	2	21.4	13.3

LTE TDD S Frame Configurations With TDD Desyncronization Distances²⁷

For base stations that are lower in height or more distant to an adjacent operator, the operator may configure the guard period ("GP") on a base station basis to a smaller value so long as the Up Pilot Time Slot ("UpPTS") uses the same number of symbols and does not cause "self-interference". Under the 3GPP LTE TDD standards, TDD is flexible enough to utilize one S frame configuration for small, closely spaced base stations in the middle of a market to prevent "self interference" while permitting a different S frame for base stations located at a market edge to avoid interference with adjacent operators.

B. Other Benefits of TDD

In addition to the two key benefits discussed above, TDD systems offer relatively lower complexity and more cost-effective design as compared to FDD systems. The fact that paired

²⁷ Table is adapted from 3GPP 36.101.

spectrum is not needed for TDD operation eliminates the need for expensive duplexers, which is highly cost-effective especially for end user devices. TDD systems require relatively fewer components and lower average PA power, leading to smaller form factors and lower equipment failure rates. In addition, TDD operation allows for accurate channel estimation of the transmit path based on the received signal characteristics. TDD systems are able to leverage this channel reciprocity to efficiently perform channel sounding/channel quality estimation as needed for performance enhancements such as dynamic sub-channel selection and beam forming applications.

For the Commission to fully realize the benefits of TDD LTE technology, the Commission should attempt to utilize channel bandwidths in multiples of 10 MHz. The 3GPP has defined LTE channel spacing in 5, 10, 15, and 20 MHz increments. Twenty MHz channels may be too large if many incumbent broadcast television licensees decline to participate in the incentive auction. If 10 MHz bandwidths are selected, there would be 8 channels available between channels 38 and 51. If, however, 12 MHz bandwidths are selected, there would be only 7 channels available between channels 38 and 51. The Commission also should attempt to avoid allocating spectrum in 6 MHz blocks, as it did with the 700 MHz band, because it may lead to less usable spectrum being made available and in turn limit the amount of auction revenue.

III. CONCLUSION

As is frequently said, spectrum is the lifeblood of the wireless industry. Many experts believe that rising consumer demand for data will only escalate in the future. To meet this demand, the Commission, should choose the most efficient band plan that will allow reallocation of the maximum amount useable of spectrum for a wide range of potential auction participants. Maximization of useful spectrum will in turn bring in more revenue for FirstNet, payment of broadcasters, and the US Treasury. A TDD band plan configuration is best suited to meet the

challenges of this complicated undertaking. By selecting a TDD band plan, the Commission will be able to meet its goals for the 600 MHz incentive auction²⁸ and work towards reaching the National Broadband Plan's goal of freeing 500 MHz for commercial use.²⁹

Respectfully submitted,

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 $^{^{28}}$ LEARN Workshop, Ruth Milkman, FCC, Chief, Wireless Telecommunications Bureau at 9.

²⁹ Federal Communications Commission, Connecting America: The National Broadband Plan, Executive Summary (rel. Mar. 16, 2010).